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Correlation Between Hemodynamic Changes and Tomographic Sestamibi Imaging During Dipyridamole-Induced Coronary Hyperemia

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Objectives. **The purposes of this study were to examine the effects of dipyridamole infusion on hemodynamic variables and to compare these changes with myocardial perfusion.**

Background. **Dipyridamole stress testing with myocardial perfusion imaging is widely used in the assessment of patients with known or suspected coronary artery disease (CAD). Few studies, however, have correlated the hemodynamic effects of dipyridamole using invasive monitoring with perfusion patterns in patients with chest pain syndromes.**

Methods. **Hemodynamic measurements were made in the cardiac catheterization laboratory with a Swan-Ganz thermodilution catheter before, during and after infusion of dipyridamole (142 μg/kg body weight per min for 4 min). Technetium-99m sestamibi was injected 3 min after the completion of the infusion.**

Results. **There were 20 patients with and 6 without CAD, as demonstrated by angiography. Compared with baseline values, dipyridamole resulted in an increase in pulmonary capillary wedge pressure (54 ± 78% vs. 32 ± 26%, p = NS), cardiac index (36 ± 21% vs. 40 ± 18%, p = NS) and stroke volume index (16 ± 18% vs. 40 ± 18%, p = NS) and a decrease in systemic vascular resistance (22 ± 13% vs. 24 ± 11%, p = NS), aortic pressure (2 ± 9% vs. 0 ± 6%, p = NS) and pulmonary vascular resistance (19 ± 25% vs. 11 ± 32%, p = NS) in patients with and without CAD. The peak effect of dipyridamole on heart rate, systemic vascular resistance and pulmonary capillary wedge pressure was evident at 3 min after infusion in 70% of patients. Aminophylline, given to 20 patients, improved hemodynamic variables within 2 min. The single-photon emission computed tomographic sestamibi images were normal in the 6 patients without and abnormal in the 18 patients with CAD.**

Conclusions. **Dipyridamole-induced coronary hyperemia produces mild hemodynamic changes in patients with and without CAD; these changes are at or near peak effect at 3 min after infusion and are rapidly reversed by aminophylline.**

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Dipyridamole myocardial perfusion scintigraphy is useful in detecting coronary artery disease (CAD) in patients with exercise limitations and has been used extensively in risk assessment in patients with stable angina after acute myocardial infarction and before major noncardiac surgery (1–11).

Intravenous dipyridamole causes coronary vasodilation by stimulation of adenosine A_2 receptors due to inhibition of cellular reuptake of endogenous adenosine (12,13). Because of the indirect action of dipyridamole, the maximal coronary vasodilation occurs some time after the completion of intravenous infusion. In addition, the vasodilatory effect of dipyridamole persists longer than that of adenosine because of the long biologic half-life of dipyridamole (~30 to 45 min). Intravenous adenosine, in contrast, is a direct coronary vasodilator with a very short half-life (14,15).

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We have previously evaluated the hemodynamic responses during adenosine infusion in patients with and without CAD and observed transient and at times marked changes in left ventricular filling pressure, cardiac output and systemic vascular resistance (16). It is unclear whether these effects are unique to adenosine or can also occur with dipyridamole. The purposes of this study were, therefore, to examine the central hemodynamic effects of dipyridamole infusion and to compare these changes with myocardial perfusion using single-photon emission computed tomographic (SPECT) imaging with technetium-99m (Tc-99m) sestamibi in patients undergoing coronary angiography for chest pain syndromes.

Methods

Patient group. This study involved patients undergoing cardiac catheterization and coronary angiography for the evaluation of chest pain syndromes (including those who were found not to have significant CAD on angiography). Each patient signed a consent form approved by the Institutional Review Board. The investigational studies were performed 20 min after completion of diagnostic cardiac catheterization. There were no complications related to the study. Patients with unstable angina, acute myocardial infarction, nonischemic

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Abbreviations and Acronyms

CAD = coronary artery disease
SPECT = single-photon emission computed tomographic
Tc-99m = technetium-99m

cardiomyopathy or chronic obstructive pulmonary disease requiring methylxanthine or beta-agonist therapy were excluded. Of the 31 patients enrolled in the study, five were subsequently excluded and did not receive dipyridamole (two with severe left main coronary artery disease and three with dilated, nonischemic cardiomyopathies). The remaining 26 patients completed the hemodynamic and imaging studies. The patients do not represent consecutive patients undergoing cardiac catheterization; the selection was based on willingness of the patients to participate in the study, time constraints and logistical considerations in coordinating the schedule of the catheterization and nuclear laboratories and personnel. All patients had stable symptoms and none had unstable angina or acute myocardial infarction.

Study design. Antianginal medications were withheld on the morning of the procedure. Arterial and venous access was obtained using the modified Seldinger technique. Standard right heart catheterization was performed using a Swan-Ganz thermodilution catheter. The following measurements were obtained: pulmonary artery pressure (phasic and mean), pulmonary capillary wedge pressure (phasic and mean) and thermodilution cardiac output using the average of three determinations. The total systemic vascular resistance (dynes·s·cm^{-5}) was calculated as (Mean aortic pressure/Cardiac output) × 80, and pulmonary vascular resistance (dynes·s·cm^{-5}) was calculated as (Mean pulmonary artery pressure − Mean pulmonary capillary wedge pressure)/Cardiac output × 80. Left ventriculography (right anterior oblique projection) and coronary angiography using iohexol nonionic contrast agent (Omnipaque, Winthrop-Breon) were performed by the Judkins technique in each patient. After the diagnostic cardiac catheterization, 20 min was allowed for hemodynamic measurements to return to baseline. The patients then received dipyridamole infusion (142 μg/kg body weight per min for 4 min) (Persantine, E. I. DuPont DeNemours). Hemodynamic measurements were recorded before infusion, during every minute of infusion and at 3-min intervals after infusion (starting at the fourth minute of infusion) and after aminophylline (100 mg administered intravenously). The duration of hemodynamic monitoring was determined by the presence and severity of side effects and patient convenience.

Three minutes after the completion of the dipyridamole infusion, 20 to 30 mCi Tc-99m sestamibi (Cardiolite, E. I. DuPont DeNemours) was injected intravenously. After removal of the venous and arterial introducer sheaths, the patient was moved to the nuclear cardiology laboratory and SPECT imaging was obtained (~60 min after sestamibi injection). The next day, 20 to 30 mCi of Tc-99m sestamibi was reinjected at rest and SPECT images were obtained 1 h later.

Single-photon emission computed tomographic Tc-99m sestamibi imaging. Single-photon emission computed tomographic scan acquisition was performed on a GE 400AT rotating gamma camera/Starcam computer system (GE Medical Systems). Thirty-two images were obtained over an anterior 180° arc according to methods previously used in our laboratory (17). The sestamibi images were interpreted by two experienced observers who had no previous knowledge of the cardiac catheterization results. The perfusion pattern was interpreted as normal or showing a fixed or reversible abnormality in the vascular territories of each of the three main vessels.

Statistical analysis. The results were expressed as the mean value ± SD. The Wilcoxon signed-rank test was used to compare the mean responses of the same group before and after dipyridamole administration, and Friedman one-way analysis of variance was used to analyze group differences. When the assumption of homogeneity of variance among groups was violated, the Kruskal-Wallis test was used. Tests of differences were done by the *t* test with the Bonferroni correction for multiple tests, or the chi-square test with Yates' correction or the Fisher exact test. Statistical differences with a value <0.05 were considered significant.

Results

There were 19 men and 7 women (age 57 ± 12 years). There were six patients without and 20 patients with CAD, defined as ≥50% lumen diameter stenosis in one or more vessels measured by quantitative coronary arteriography (using the Analytic Development Associate Corporation edge-detection method); nine patients had one-vessel disease; seven patients had two-vessel disease; and four patients had three-vessel disease. Collateral channels were visible on the angiogram in eight patients (40%). The patients without CAD were younger than the patients with CAD. More patients with than without CAD had diabetes mellitus or were taking antianginal medications. The mean left ventricular ejection fraction was normal in patients with and without CAD (Table 1).

Hemodynamic changes during dipyridamole infusion (Tables 2 and 3). The baseline hemodynamic measurements (before dipyridamole infusion) in patients with and without CAD are presented in Table 2. The patients with CAD had a slightly lower stroke volume index and higher pulmonary vascular resistance than patients without CAD ($p < 0.05$).

The hemodynamic changes after dipyridamole infusion in patients with and without disease are shown in Table 3. There was no significant change in aortic pressure owing to directionally opposite changes in cardiac output and systemic vascular resistance. The increase in heart rate was less in patients with than in those without CAD. There were increases in pulmonary capillary wedge pressure and pulmonary artery pressure (more marked in patients with than in those without CAD, $p < 0.05$) and a decrease in pulmonary vascular resistance. The increase in cardiac index was similar in patients with and without CAD. The increase in cardiac index was due to

Table 1. Pertinent Data in Patients With and Without Coronary Artery Disease

	CAD (n = 20)	No CAD (n = 6)	p Value
Age (yr)	60 ± 11	48 ± 12	0.04
Male/female	13/7	6/0	NS
Typical angina	16 (80%)	2 (33%)	NS
Q wave myocardial infarction	10 (50%)	0 (0%)	NS
Hypertension	11 (55%)	4 (67%)	NS
Diabetes mellitus	5 (25%)	0 (0%)	NS
Family history of CAD	11 (55%)	3 (50%)	NS
Nitrates	9 (45%)	1 (17%)	NS
Beta-blockers	8 (40%)	2 (33%)	NS
Calcium channel antagonists	13 (6.5%)	0 (0%)	0.02
Left ventricular ejection fraction	60 ± 9	67 ± 3	NS
Coronary anatomy			
One-vessel disease	9 (45%)		
Two-vessel disease	7 (35%)		
Three-vessel disease	4 (20%)		
Visible collateral vessels	8 (40%)		

Data presented are mean value ± SD or number (%) of patients. CAD = coronary artery disease.

increases in heart rate and stroke volume. The decrease in systemic vascular resistance was greater than the decrease in pulmonary vascular resistances ($p < 0.005$). The change in pulmonary capillary wedge pressure was 40 ± 21% in five patients who had dyspnea and 60 ± 70% in those without it (p = NS). The increase in wedge pressure was 81 ± 84% in 14 patients with normal baseline pressure (<12 mm Hg) and 31 ± 17% in patients with elevated pressure ($p < 0.05$). The change in wedge pressure was 98 ± 99% in seven patients with an anteroseptal perfusion abnormality compared with 43 ± 44% in 19 patients with no anteroseptal defect (p = NS).

Timing of hemodynamic responses. The time to peak effect of various hemodynamic responses is shown in Figure 1. In most patients (70%), the peak effect was evident at 3 min after infusion; the change between 3 and 7 min after infusion was minimal (Table 3). In eight patients with CAD and one patient without CAD, prominent V waves (>30 mm Hg) were evident in pulmonary capillary wedge pressure tracings after dipyridamole infusion (Fig. 2). Of the patients with CAD, three had one-vessel disease, three had two-vessel disease and two had three-vessel disease. Collateral channels were present in five of the eight patients with CAD and prominent V waves compared with three of 12 patients with CAD but no large V waves (p = NS). All five patients who developed ST segment changes during dipyridamole infusion had CAD and also developed prominent V waves. Collateral channels were present in four of the five patients with ST segment depression. No patients without CAD had ST segment depression.

Table 2. Baseline Hemodynamic Values in Patients With and Without Coronary Artery Disease

	CAD (n = 20)	No CAD (n = 6)	Total Group (n = 26)
Heart rate (beats/min)	76 ± 12	69 ± 15	75 ± 13
Aortic systolic pressure (mm Hg)	154 ± 27	139 ± 23	151 ± 27
Mean PAP (mm Hg)	19 ± 4	18 ± 4	18 ± 4
Mean PCWP (mm Hg)	12 ± 4	12 ± 3	12 ± 3
Cardiac index (liters/min per m^2)	3.2 ± 0.5	3.4 ± 0.8	3.2 ± 0.6
Stroke volume index (ml/beat per m^2)	42 ± 5*	50 ± 8	44 ± 7
Total SVR (dynes·s·cm^{-5})	1,410 ± 325	1,137 ± 274	1,347 ± 331
PVR (dynes·s·cm^{-5})	93 ± 33*	57 ± 32	85 ± 35

*$p < 0.05$ versus no coronary artery disease (CAD). Data presented are mean value ± SD. PAP = pulmonary artery pressure; PCWP = pulmonary capillary wedge pressure; PVR = pulmonary vascular resistance; SVR = systemic vascular resistance.

In patients with CAD, the changes in pulmonary artery pressure, pulmonary capillary wedge pressure, cardiac output, aortic pressure and systemic vascular resistance were comparable between patients with collateral channels (n = 8) and those with no collateral channels (n = 12).

Effects of aminophylline. Aminophylline was given to 13 patients with CAD (65%) and one patient without CAD (p = NS) for persistent symptoms (Table 4). Chest pain was the most common side effect occurring in patients with and without CAD. Heart rate, mean pulmonary artery pressure and pulmonary capillary wedge pressure rapidly decreased after aminophylline administration. These variables returned to baseline by 5 min in most patients (Table 3). Resolution of symptoms occurred within 2 min of administration.

Single-photon emission computed tomographic Tc-99m sestamibi imaging. All six patients without CAD had normal images (specificity 100%), whereas 18 of the 20 patients with disease had perfusion abnormalities (sensitivity 90%). In 16 patients, the perfusion defects were either partial or completely reversible. In the remaining two patients, only fixed defects were seen. Perfusion defects were seen in seven of nine patients with one-vessel disease, seven of seven patients with two-vessel disease and four of four patients with three-vessel disease. Reversible perfusion defects were seen in five of five patients with ST segment depression. In patients with multivessel disease, perfusion defects were detected in 16 of 26 stenoses. The stenosis severity was 80 ± 18% in those with defects and 64 ± 15% in those without defects as demonstrated by quantitative angiography ($p < 0.01$). There was no relation between the extent of perfusion abnormality, measured as the number of segments (based on a model of 20 segments per patient) with perfusion abnormalities, and the peak pulmonary capillary wedge pressure during dipyridamole infusion (r = 0.27, p = NS) (Fig. 3). The size of the defect was 4.9 ± 3.3 segments in the eight patients who developed prominent V waves and 3.6 ± 3.5 segments in those who did not (p = NS).

Discussion

This study showed that the standard dose of intravenous dipyridamole (142 μg/kg per min for 4 min) caused mild but significant hemodynamic changes for several minutes after termination of infusion, which reverted promptly to baseline

Table 3. Percent Change in Hemodynamic Measurements From Baseline to During and After Dipyridamole Stress

Hemodynamic Variable	Time Since Start of Dipyridamole Infusion				1 Min After Aminophylline	5 Min After Aminophylline
	4 Min	7 Min	10 Min	13 Min		
HR (%)						
CAD	13 ± 12*	18 ± 15*†	16 ± 14*†	14 ± 12*†	10 ± 13*†	0 ± 11†
No CAD	28 ± 16*	31 ± 12*	25 ± 11*†	26 ± 16*	14 ± 20	NA
SBP (%)						
CAD	−3 ± 8	−2 ± 9	0 ± 12	0 ± 13	4 ± 10	−2 ± 10
No CAD	0 ± 10	0 ± 6	1 ± 5	1 ± 8	0 ± 5	NA
Mean PAP (%)						
CAD	13 ± 20*	30 ± 30*†	34 ± 41*	23 ± 27*	16 ± 34†	−4 ± 25†
No CAD	9 ± 11	20 ± 14*†	21 ± 21	22 ± 19*	−2 ± 16	NA
Mean PCWP (%)						
CAD	17 ± 23*	48 ± 52*†	54 ± 78*	40 ± 55*	38 ± 63*	2 ± 43†
No CAD	−2 ± 25	23 ± 14*†	32 ± 26*	21 ± 29	−1 ± 42	NA
CI (%)						
CAD	32 ± 22*	36 ± 21*	34 ± 22*	32 ± 26*	NA	NA
No CAD	44 ± 19*	40 ± 18*	40 ± 22*	NA		
SVI (%)						
CAD	16 ± 16*	16 ± 18*	16 ± 16*	17 ± 20*	NA	NA
No CAD	44 ± 19*	40 ± 18*	40 ± 22*	NA		
Total SVR (%)						
CAD	−20 ± 14*	−22 ± 13*	−22 ± 14*	−11 ± 15†	NA	NA
No CAD	−27 ± 10*	−24 ± 11*	−26 ± 14*	NA		
PVR (%)						
CAD	−13 ± 29	−19 ± 25*	−15 ± 32	2 ± 28	NA	NA
No CAD	−15 ± 25	−11 ± 32	−22 ± 43	NA		

*$p < 0.05$ versus baseline value. †$p < 0.05$ versus previous stage. Data presented are mean value ± SD. CI = cardiac index; HR = heart rate; NA = not available; SBP = systolic blood pressure; SVI = stroke volume index; other abbreviations as in Table 2.

after aminophylline administration. There were increases in heart rate, stroke volume and cardiac index and decreases in systemic and pulmonary vascular resistance in patients with and without CAD. The pulmonary capillary wedge pressure increased slightly in patients with and without CAD, and some patients with CAD developed prominent V waves. Most patients (90%) with CAD had abnormal SPECT images, whereas the patients without CAD had normal images.

Hemodynamic changes during dipyridamole infusion. Many studies have demonstrated that intravenous adenosine and dipyridamole produce a slight increase in heart rate and a slight decrease in blood pressure, and thus only a modest change in rate–pressure product (18–25). The increase in heart rate may be related to adenosine-induced sympathetic stimulation, or as reflex tachycardia secondary to hypotension (26–30). The decrease in systemic blood pressure is probably caused by a direct vasodilatory effect on systemic circulation through activation of adenosine A_2 receptors. The lack of significant changes in systemic blood pressure in this study may be related to volume expansion as a result of coronary angiography and left ventriculography. In a recent study, Taillefer et al. (31) reported a greater decrease in systolic blood pressure with adenosine than with dipyridamole (−12 ± 11 vs. −5 ± 10 mm Hg, $p < 0.001$).

Few studies in humans have evaluated the effects of adenosine and dipyridamole on hemodynamic changes using invasive monitoring in patients with chest pain syndromes. Miller et al. (23) evaluated the early hemodynamic changes induced during dipyridamole pharmacologic stress in 10 patients early after myocardial infarction. They noted a significant increase in heart rate in association with a decrease in mean arterial pressure and an increase in mean pulmonary capillary wedge pressure (from 13 ± 5 to 17 ± 6 mm Hg) with the development of large V waves in the pulmonary capillary wedge pressure tracings in some patients. The development of large transient V waves was most prominent in patients with a recent anterior wall myocardial infarction. In addition, they showed a significant increase in cardiac index and a decrease in systemic vascular resistance at peak effect. These hemodynamic responses were rapidly reversed with intravenous aminophylline.

We previously reported on the hemodynamic responses during intravenous adenosine administration in patients with and without CAD (16). In that study, the increase in pulmonary capillary wedge pressure was greater in patients with than in those without CAD. The patients who had V waves during adenosine infusion did not develop mitral regurgitation (on ventriculography) or wall motion abnormality. The other hemodynamic responses (heart rate, aortic pressure, cardiac output and vascular resistance) were similar in patients with and without CAD.

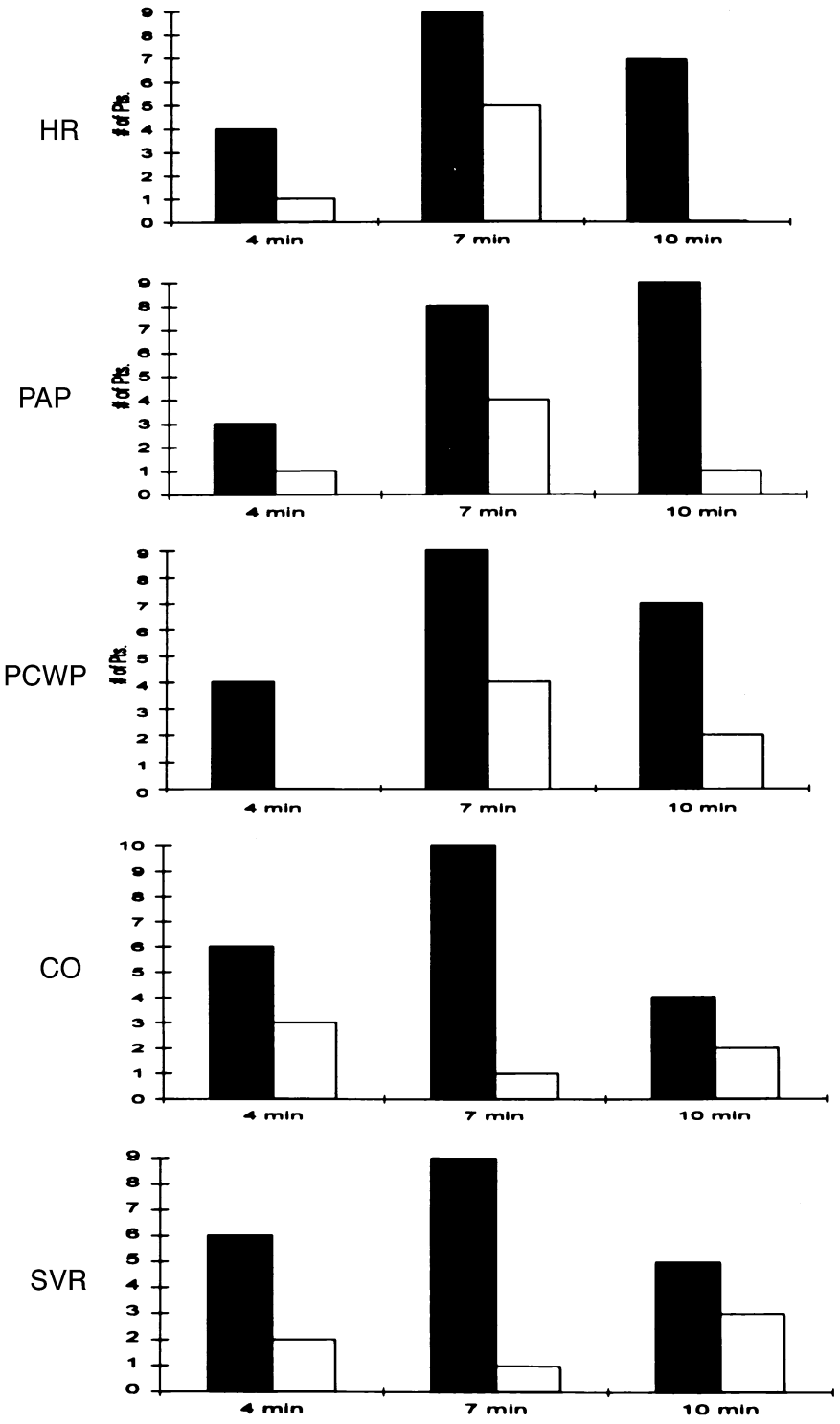

Figure 1. Time to peak hemodynamic effects during dipyridamole stress. Number of patients (Pts.) with and without coronary artery disease (CAD) is shown in relation to peak hemodynamic effect. CO = cardiac output; HR = heart rate; PAP = pulmonary artery pressure; PCWP = pulmonary capillary wedge pressure; SVR = systemic vascular resistance. **Solid bars** = CAD; **open bars** = no CAD.

A prominent V wave was seen in 8 of 20 patients with CAD in the present study. All five patients with CAD who developed ST segment changes during dipyridamole also developed prominent V waves. Although there may be differences between our previous patients and those enrolled in the present study, the changes in hemodynamic data were more marked during adenosine infusion. These differences between adenosine and dipyridamole may be related to interstitial levels of adenosine. The study by McLaughlin et al. (28) also showed only modest changes in pulmonary capillary wedge and pulmonary artery pressures during dipyridamole infusion. In the same study, there was also only a modest increase in the coronary sinus level of adenosine during administration of a standard dose of dipyridamole. It is unclear whether a larger

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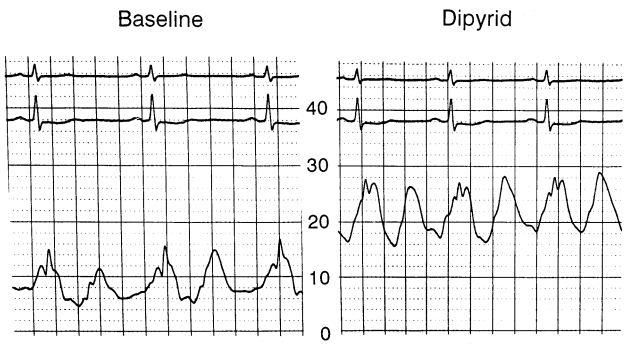

Figure 2. Tracings of aortic pressure and pulmonary capillary wedge pressure before (**left**) and after (**right**) dipyridamole (Dipyrid) infusion. There is a marked increase in pulmonary capillary wedge pressure.

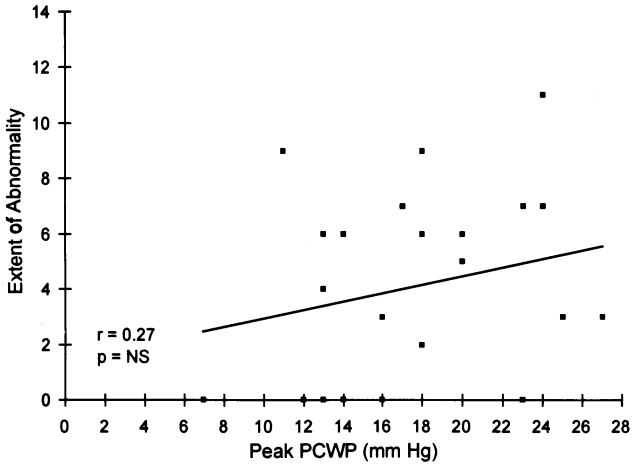

Figure 3. The relation between peak pulmonary capillary wedge pressure (PCWP) and the extent of perfusion abnormality. No statistically significant correlation was noted.

dose of dipyridamole, as used in many laboratories in Europe, may have produced a more marked hemodynamic response. The study by Czernin et al. (32), however, showed no further increase of myocardial blood flow (measured with nitrogen-13 ammonia and positron emission tomography) with the higher dose compared with the standard dose. The changes in pulmonary capillary wedge pressure during adenosine or dipyridamole infusion may be related to several factors such as increased left ventricular stiffness, myocardial ischemia or increased preload. Ren et al. (33) studied the changes in myocardial blood volume during adenosine infusion by two-dimensional echocardiography and showed a greater increase in patients with than in those without CAD. Nussbacher et al. (34) suggested that an increase in preload (due to dipyridamole effects on capacitance vessels) may be responsible for the elevation of filling pressure. The failure of normalization of the wedge pressure 1 min after aminophylline administration, which blocks adenosine receptors and thus should have an instantaneous effect, is not clearly understood. It may support the preload concept, but further studies are needed to provide insights into the mechanism of rise in wedge pressure. The greater increase in pulmonary capillary wedge pressure seen in our previous study with adenosine compared with dipyridamole may reflect a difference in the patient group, a difference in the degree of coronary hyperemia, coronary steal or the degree of change in preload. Previous studies have shown similar increases in myocardial blood flow with adenosine and dipyridamole, although Chan et al. (35) observed that maximal hyperemia is not seen in roughly 25% of patients given dipyridamole. It should be noted that although an average 50% increase in wedge pressure was seen in this study, the absolute wedge pressure increased only from 12 to 18 mm Hg. The dyspnea, or more appropriately hyperventilation, observed with dipyridamole or adenosine is most often caused by stimulation of carotid chemoreceptors (13).

Table 4. Frequency of Side Effects During Dipyridamole Infusion in Patients With and Without Coronary Artery Disease

	CAD (n = 20)	No CAD (n = 6)	p Value
Cardiac			
Dyspnea	5 (25%)	0 (0%)	NS
Chest pain	16 (80%)	3 (50%)	NS
ST segment depression	5 (25%)	0 (0%)	NS
Atrioventricular block (2nd degree, type 1)	1 (5%)	1 (17%)	NS
Noncardiac			
Headache	5 (25%)	1 (17%)	NS
Flushing	4 (20%)	0 (0%)	NS
Nausea	0 (0%)	0 (0%)	NS
Epigastric discomfort	2 (10%)	0 (0%)	NS
Aminophylline treatment	13 (65%)	1 (17%)	NS

Data presented are number (%) of patients. CAD = coronary artery disease.

Time to peak hemodynamic response. The time to peak effect after dipyridamole infusion was at 3 min after infusion in most patients, consistent with experimental data (36). From the clinical standpoint, it seems that injection of radiotracer at 3 to 6 min after termination of infusion, as is currently done, is appropriate. Several studies evaluating the effects of dipyridamole on coronary flow and myocardial metabolism have demonstrated peak dipyridamole effect at comparable times. Wilson and White (37) compared the coronary vasodilatory effect of intravenous dipyridamole with intracoronary papaverine and meglumine diatrizoate in patients with normal coronary circulation. Coronary blood flow velocity increased to 4.8 times the rest value at the completion of the 4-min dipyridamole infusion (using a similar infusion protocol as in the present study). This value was 87% of the maximal flow velocity achieved with papaverine, and was reached at ~6.5 min (range 3.6 to 7.9) after the onset of the infusion. In Wilson and White's study, maximal vasodilation persisted for 1.7 to 5.1 min after achieving maximal coronary blood flow velocity. Feldman et al. (18) demonstrated that coronary hyperemia, induced by a 20-mg intravenous bolus of dipyridamole, yielded changes in regional coronary blood flow and metabolic responses that were dependent on the status of the arteries supplying the left

ventricular region. By 1 min after dipyridamole administration, the heart rate increased and the systemic blood pressure decreased significantly compared with baseline values; these changes persisted >10 min. Total left ventricular myocardial flow (measured by a flow catheter in the coronary sinus) increased significantly by 34 s after dipyridamole infusion, increased to 51% above baseline flow by 1 min and continued to be elevated 15 min after injection. Seven of 13 patients had an increase of peak response by 1 min, 4 patients by 5 min and 2 patients by 10 min. Increased coronary blood flow in normal regions accounted for >75% of the increase in coronary blood flow. In patients with CAD, flow did not increase in the myocardium supplied by a stenotic coronary artery.

Marchant et al. (38) compared the hemodynamic effects of intracoronary versus systemic dipyridamole administration on coronary blood flow. They suggested that coronary hyperemia may be due to both direct coronary vasodilation and an increased double rate–pressure product. Intracoronary dipyridamole achieved a peak level of coronary sinus flow (increase of 73% from baseline) by 1 min, with minimal hemodynamic changes. In contrast, intravenous dipyridamole augmented coronary sinus flow by an additional 88%, with the peak effect occurring 5 min after administration.

Study limitations. One potential limitation of the study is the small sample size, especially the group without CAD. We also excluded patients with more severe disease or severe left ventricular dysfunction. Some studies have combined exercise (isometric or dynamic) with dipyridamole to maximize coronary hyperemia and increase the double product. Because this study was performed in the cardiac catheterization laboratory, the effect of exercise was not studied. However, Czernin et al. (32) have shown that the combination of isometric exercise with dipyridamole may result in a decrease rather than a further increase in coronary blood flow compared with dipyridamole alone.

The effects of cardiac medications, contrast material and volume loading on hemodynamic responses should also be considered. Although in this study, we tried to limit the amount of contrast material and allowed 20 min after catheterization before the start of the dipyridamole infusion.

Conclusions. Dipyridamole infusion is associated with mild hemodynamic changes in patients with and without CAD. Most changes are near peak effect at 7 min from the start of the infusion. These hemodynamic abnormalities are reversed by aminophylline and are less prominent than those observed with adenosine. Thus, in dipyridamole perfusion imaging, the radiotracer may be injected at 7 to 10 min after the start of the infusion. The prolonged hemodynamic response may potentially be of benefit to enhance extraction of technetium-labeled tracers.

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